THE EFFECT OF SALIVARY CONTAMINATION ON MICROLEAKAGE OF COMPOSITES BONDED WITH CURRENT GENERATION ADHESIVES – AN IN-VITRO STUDY

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CERTIFICATE

Certified that the dissertation on" **THE EFFECT OF SALIVARY CONTAMINATION ON MICROLEAKAGE OF COMPOSITES BONDED WITH CURRENT GENERATION ADHESIVES"** done by **Dr.A. RENUGA LAKSHMI,** post graduate student (MDS), Branch VIII – Pedodontics and Preventive Dentistry, Saveetha Dental College and Hospitals, Chennai submitted to The Tamil Nadu Dr. M.G.R. Medical University in partial fulfillment for the M.D.S degree examination in March 2007, is a bonafide research work done under my guidance and supervision.

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A.RENUGALAKSHMI

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This dissertation is dedicated to my beloved parents…

INTRODUCTION

INTRODUCTION

Materials that bond to enamel and dentin have revolutionized dentistry. Whether it is a pit and fissure sealant or a composite restoration or fixing of orthodontic brackets, the stability of the bond is paramount to clinical success. [1] A portion of the bonding field involves composite materials which bond to enamel, depend on a clean and architecturally microporous enamel surface produced by acid etching. One of the major reasons of a poor or failed bond is salivary contamination of the etched enamel surface before resin placement. [2]

Buonocore defines adhesion as the molecular attraction between the surface of bodies in contact, or the attraction between molecules at an interface. This adhesion exists only if the separation is very slight (0.0001 to 0.0002 micro mm). Saliva and to a lesser extent other types of moisture are capable of increasing the amount of separation between etched surface and the resin composite, thus decreasing the adhesion.[3] An acid conditioned enamel surface really absorbs salivary constituents, thereby reducing the surface energy and rendering the surface less receptive for bonding.[4]

Several studies have suggested that the clinical success of resin bonding systems to enamel could be jeopardized by contamination with oral fluids. [3,5, 6,7] **L.M. Silverstone et al (1985)**[1] showed that contamination of the etched enamel with oral fluids , even for a single second resulted in an adherent tenacious organic surface coating that is not easily removed by conventional washing techniques .

For decades it has been a clinically accepted requirement, in case of salivary contamination, to re-etch conditioned enamel and dentin, prior to proceeding with the adhesive technique.[4] But with the advent of "single bottle" adhesive technique, there seems to be a change of opinion. The majority of these adhesives can be applied to moist surfaces which, if contaminated by salivary protein, might prevent monomers from penetrating the pores in enamel or the collagen network of dentin following acid conditioning. It was hypothesized that such hydrophilic adhesive solutions, in particular the acetone or ethanol based products, may displace or diffuse through a saliva film to reach the underlying hydroxyapatite or collagen for firm bonding after polymerization .[4]

Very few reports have been published so far dealing with the potential of single -bottle bonding agents to bond even when applied after salivary contamination and without re-etching. The results so far suggested that single-bottle adhesives are relatively insensitive to contamination by saliva.[9, 10]

The following current generation adhesives were used in the present study. Adper Single Bond 2, Gluma and Excite being the single bottle adhesives, Syntac a two bottle adhesive and lastly Prompt L Pop as a mixture of etchant, primer and adhesive. The purpose of this study was to evaluate the effect of salivary contamination on microleakage of composites bonded with current generation adhesives.

AIMS AND OBJECTIVES

The present in-vitro study was conducted with the following objectives in mind:

1. To evaluate the effect of salivary contamination on microleakage of composites bonded with five different current generation adhesives.

2. To study the performance of these five different adhesives in different surface treatment conditions (uncontaminated, saliva contamination and blot dried, saliva contamination and water rinsed).

3. An inter group comparison of the performance of each of five current generation adhesives in different surface treatment conditions.

REVIEW OF LITERATURE

REVIEW OF LITERATURE

The science of bonding of dental material to tooth structure got a shot in the arm with the **Buonocore's(1955)** postulation that acids could be used as a surface treatment before application of the resins. He subsequently found that etching of enamel created a micro porous surface into which direct filling liquid resin could flow, polymerize and make a micromechanical attachment.

Baier RE and Glantz P(1978)[12] conducted studies on oral films formed in-vivo, which had been allowed to form on fused silica and Ge-prisms during periods between 2 seconds and 2 hours using a variety of physico-chemical methods. The results showed that the formation of oral films proceeds at high speed and is of a certain quantitative selectivity. The adsorbed proteinaceous matter is in a considerably looser and more native configuration. Low surface energy materials in the oral cavity might be much more easily cleaned of built up-films of protein and subsequently of adherent formed elements because of the loose weakly adherent film structure. The maximum amount of dental integument that can adhere to a solid surface depends on the magnitude of critical surface tension of that surface. According to them these findings should be kept in mind while dealing with formation of oral films.

Silverstone et al (1985)[1] conducted an in-vitro study to determine the effects of differing salivary contamination periods on the surface topography of etched enamel surface using Scanning Electron Microscope. The results indicated that salivary contamination of etched human enamel for 1 second resulted in the formation of surface coating that could not be removed by a usual wash. It was concluded that if salivary contamination of an etched enamel surface occurs, it would be necessary to repeat the etching procedure to obtain adequate bonding of a resin material.

Knud Dreyer Jorgenson et al (1985)[13] measured the wall-to-wall polymerization contraction of a light cured composite material with and without the use of five different dentin bonding agents in cylindrical dentin cavities prepared in extracted human teeth either fresh or after storing for 1 or 4 weeks in four different media. No effect of the storing conditions on the widths of contraction gaps could be demonstrated when the teeth were stored either in tap water or in 1 % aqueous chloramine solution.

Ballesteros et al(1986)[14] examined the influence of potential sources of contamination on resin bond strength to a base metal alloy. This in-vitro study showed that there is no apparent effect of saliva contamination on the bond strength of resin to etched metal.

W.S. Eakel (1986)[15] studied the effect of thermocycling on fracture strength and microleakage in teeth stored with a bonded composite resin. The results of this in-vitro study suggest that variations in temperature in a clinical range may reduce the fracture strength gained with bonded posterior composite resins. Polymerization shrinkage may produce significant microleakage even before thermocycling of the teeth.

O Brien JA et al (1987)[6] conducted an in-vitro study on human canines to determine the effects of a phosphoric acid gel and saliva contamination on etched enamel to tensile bond strength of a composite resin. The results showed that bond strength of composite resin to etched enamel surfaces contaminated with saliva for 15 seconds and washed for 15 seconds was not significantly different from that of enamel surface that was similarly treated but re-etched for 15 seconds. They question the practice of re-etching of enamel surfaces even after a brief exposure to saliva after etching.

Mejare et al (1987)[16] conducted an in-vivo study on human premolars to ascertain if bacteria due to saliva contamination during the procedure survive under tightly sealed composite restorations. The results showed no growth of bacteria under the composite resin restorations, independent of whether the cavity was washed with water or with an antimicrobial agent before filling. They suggest that bacteria originating from saliva contamination do not seem to survive under tightly sealed composite resin restorations.

Gary A Crim et al (1987)[17] conducted a in-vitro study to evaluate the effect of storage and thermocycling duration on microleakage. The investigation revealed that the limited storage time or thermocycling duration used had no significant impact on the microleakage patterns of resin bonded composites in Class I preparation.

D. R. Powis et al (1988)[18] used radiochemical diffusion technique for long term monitoring of microleakage in three types of composites. The radioactive tracer used was a beta-emitting solution of 14C sucrose. The results stated that the extent of microleakage of the composite restoration is related to particular materials used. Acid etching of enamel cavity walls can significantly reduce with time because of the hygroscopic expansion of the resin.

A.C. Shortall(1988)[19] did a long term monitoring of microleakage of adhesives using Scanning Electron Microscope. This study assessed the relationship between tag formation and microleakage. He concluded that there was a significant correlation between etched enamel adaptation of composite and microleakage. This study revealed that different adhesive types results in different tag quality and replication of acid-etched enamel wall.

B. Torstenson and A. Oden et al (1989)[20] studied the effect of different bonding agent types and incremental techniques on minimizing contraction gaps around resin composites. Different bonding techniques like Bowen's system, Scotchbond or Gluma and various techniques were tested using P-10 composite resin. The contraction gap was demonstrated by use of the resin impregnation technique. It was concluded that the lowest mean gap width value was obtained for Gluma in combination with Clearfil bonding agent. Placement of the composite in two increments significantly reduced the gap width. No reduction was achieved when a three-step technique was used.

Hansen et al (1989) [21] conducted an in-vitro study on human dentin to find the efficacy of two dentin bonding agents , Gluma and Scotchbond dual cure , with or without saliva contamination of the dentin, before or after the application of the adhesive. When the dentin surface was contaminated, the shear bond strength was reduced but difference between the contaminated and uncontaminated specimens were not statistically significant. If the contamination was after the application of the adhesive, the efficacy of the Gluma was further reduced, while that of Scotch bond was significantly improved.

Gary A Crim(1989)[22] evaluated the compatibility of bonding agents and composites on microleakage. In addition, the influence of the types of composite resins on microleakage was investigated. Microleakage was evaluated under a measuring microscope with a help of basic fuschin dye. Microleakage was greatly reduced when a less viscous microfilled composite resin was used in conjunction with various bonding agents. This study concluded that the higher viscosity and lower sorption values of some composite resins might adversely influence microleakage regardless of bonding agent used.

Barghi et al (1991)[7] suggested that the rubber dam isolation is considered the best means for moisture control for the etched surface. In a survey conducted by **Hagge et al in 1984**, use of rubber dam as a means of moisture control has declined among dentists who graduated after 1980.[17]

Pashley (1991)[23] in his elaborate review on dentin bonding suggests that salivary contamination can lower the bond strength of resin enamel bonds and resin dentin bonds but he presumed that contaminated dentin surfaces might cause lower bond strengths depending on the bonding systems, like original Scotchbond more sensitive to surface contamination than Scotchbond 2.

Kanca III (1992)[24] in an in-vitro study evaluated the bond strength of the All bond adhesive systems to dry and moist dentin, Dentin bond strength was greatly improved by bonding of moist etched dentin. The author concluded that , acetone facilitated spreading of the primer over the water coated surface, chasing the water and carrying primer resins into the dentinal surface.

Kanca III (1992)[25] suggested that the addition of acetone to water raises the vapor pressure of water, so that some of it volatizes away from the dentinal surface. The addition of acetone also causes the surface tension of water to be reduced. Thus the acetone–resin mixture chases the water until equilibrium is reached. The increased bond strength when single bottle adhesives were used is a result of deposition of the adhesive in intimate adaptation to the surface of the dentin and tubule walls.

Vassiliakis et al (1992)[26] in an in-vitro study assessed the influence of concentration of salivary proteinaceous material from solution of whole saliva on the kinetics of pellicle formation. The results showed that the adsorption of salivary proteins is a very rapid process on both types of surfaces, namely hydrophobic and hydrophilic. Part of the biofilm, desorbed upon rinsing indicating that the proteinaceous material was adsorbed with varying binding strengths. Larger adsorbed amounts were recorded on hydrophobic than on hydrophilic surfaces.

B Van Meerbeek et al (1992)[27] reviewed factors affecting adhesion to mineralized tissues, the physicochemical structure of the adherents, the inherent properties of composite restorative materials, along with the postulated bonding mechanism of current adhesive systems.

Janet C Hitt et al (1992)[4] did an in-vitro study to evaluate the use of a bonding agent to reduce sealant sensitivity to moisture contamination. The contamination treatment groups included fresh whole saliva, air dried; fresh whole saliva, left wet, moisture from a humidity chamber. They observed that the bonding agent under sealant on wet contamination yielded bond strengths equivalent to the bond strength obtained when sealant was bonded directly to clean, etched enamel. When the saliva was air dried, there was no significant difference in bond strengths whether or not a bonding agent was used under the sealant.

Wendt SL et al (1992)[28] studied the effect of thermocycling on dye penetration during in vitro microleakage analysis of composites . The results showed no significant increase of microleakage in restorations when thermocycling was used.

RL Eriksen (1992)[29] noted that, " A basic tenet of adhesion is that the adhesive liquid must be into close contact with the substrate to facilitate molecular attraction and allow either chemical or micromechanical surface attachment."

Harald et al (1993)[30] suggested that traditional dentinal adhesives research had focused on material factors rather than important clinical variables. Many other factors are as important as the adhesive material itself. Dentin factors, tooth factors and patient factors as well as material factors must be jointly understood and related in the overall "bonding equation".

Hugo Reteif et al (1993)[31] determined the shear bond strength and quantitative microleakage of Class V preparations in dentin restored with Syntac System. The results showed that bonding resin penetrated deeply into the dentin.

Fiegal et al (1993)[2] conducted an in-vitro study to verify the effectiveness of using an adhesive agent in bonding a pit and fissure sealant in saliva contaminated conditions Versus sealant placed in contaminated and uncontaminated enamel. The results showed that sealant failed miserably when used alone in contaminated conditions but use of bonding agent with sealant considerably increased the chance of success. Sealants placed on etched, rinsed and dried enamel subsequently contaminated with saliva for 10 seconds before sealant application retained for 2 years if an intervening layer of Scotchbond adhesive system is placed and air thinned between contaminated enamel and sealant. Without this layer, the sealant was lost in one week.

Knight et al (1993)[3] in an in-vitro study measured and compared the degree of dye penetration at the composite enamel interface of samples that were bonded during isolation using either a rubber dam or cotton rolls to determine the possible effects of isolation methods on microleakage. It was found that specimens bonded with unfilled resin during rubberdam isolation displayed significantly less microleakage than that demonstrated by the specimens isolated by cotton rolls.

Xie J et al (1993)[32] in an in-vitro study on human tested bond strength of enamel and dentin treated with five contaminants. The contaminants used were artificial saliva, human plasma, zinc oxide cement, non-eugenol cement and a hand piece lubricant. The bonding agents used were a lower viscosity, solvent containing type All bond and a higher viscosity hydrophilic monomer type Scotchbond. Results suggested that although bonding agents were sensitive to contaminants, they are less sensitive than typically assumed. Re-etching without additional mechanical preparation was found to be sufficient to provide adequate bond strength.

Andrew L Sonis (1994)[32] did an in-vitro study to compare the bond strengths of brackets applied to contaminated and uncontaminated enamel following pretreatment of the contaminated enamel with the Scotchbond MP Bonding system and found that the bond strengths of orthodontic brackets under the treated conditions were comparable.

Perdiago et al (1994)[34] suggested that strong durable bonds between dental biomaterials and tooth substrates are essential, not only from a mechanical stand point, but also from biologic and esthetic perspective [43].

Rossomando KJ et al (1995)[35] studied the effect of thermocycling and dwell times in microleakage evaluation for bonded restorations. Results showed that dwell time should be clinically relevant. During microleakage analysis, the need for thermocycling is dependent upon the extent the restoration is thermally conductive in relation to its mass.

Fitchie JG et al (1995)[36] studied the microleakage of a new dental adhesive microfilled and hybrid resin composites. Class V cavities were prepared and microleakage was evaluated at 1 week with a 45 Ca radioisotope method. It was found that Syntac /hybrid resin restoration leaked less than did the Syntac /microfilled resin restorations, however this difference was not statistically significant.

Reeves GW et al (1995)[37] evaluated the microleakage behaviour of three bonding systems and also determined that bovine teeth are comparable substrates to human teeth when studying microleakage of various materials. The results showed no statistically significant differences in microleakage among the bonding systems for the human substrate. No statistically significant differences between the microleakage behavior of human and bovine substrate were found. The results support the use of bovine teeth fit in in-vitro microleakage studies.

Jacobsen et al (1995)[38] did a in-vitro study to determine how the bond strength of HEMA based dentin primers are affected by different solvents (water or acetone). It was found that compared to acetone, water is inferior as a solvent for HEMA based dentin primers and gives lower bond strength and requires longer priming time than acetone. A possible explanation is the ability of water to interfere with the polymerization of the resin systems.

Walshaw et al (1996)[39] in a review article discusses factors of clinical relevance in achieving optimal dentin bonding. They say a thin, uniform layer of bonding resin is a critical, elastic intermediary for absorbing stress of polymerization shrinkage. An air stream should be used only for evaporation of solvent and not for spreading bonding resin, because use of an air stream causes an uneven thinning of this valuable intermediary layer. Contamination of the dentinal surfaces with excessive moisture or solvent or the presence of air voids will make bonding unpredictable under clinical conditions.

AUJ Yap et al (1996)[40] compared the in-vitro effectiveness of a new adhesive Scotchbond MP dental adhesive system with an established product, Gluma Bonding system in preventing microleakage and the influence of storage, thermal and load cycling on microleakage patterns. The authors concluded that Gluma Bonding system provided a better seal against dye penetration at both cervical and occlusal margins than Scotchbond MP. Mechanical load cycling had no significant influence on the leakage patterns. The leakage at the composite-dentin interface was generally greater than that at the composite–enamel surface.

Choi et al (1997)[41] conducted an in-vitro study to compare the bond strength of sealants to bovine enamel without and with primer as an intermediary layer. In this study, higher shear bond strength were obtained by using primer even though the surface was wet. This study also showed that primer used on moist enamel under sealant had significantly higher bond strength than sealant on dry enamel. The increase in bond strength is expected to result in better retention of sealants in clinical use.

E. Bonilla Z Yu (1997)[42] compared microleakage of four new "single" component dentin bonding agents to three conventional multicomponent dentin bonding agents. Standardized Class V cavity preparations were made in 140 freshly extracted molars. All materials performed well and "single" component systems were not inferior to multicomponent system.

Marco Ferrari et al (1997)[43] investigated the formation of hybrid layer, resin tags and adhesive lateral branches by the use of Prime and Bond 2.1, Single bond and Syntac of enamel Dentin bonding systems. In order to obtain a retentive interlocking between resins, enamel and dentin, both enamel and dentin must be etched before applying the primer adhesive solution.

AUJ Yap et al (1998)[44] et al evaluated in an in-vitro study the enamel and dentin marginal sealing ability of four new generation composite bonding systems. They tested the Scotch bond MP, Fuji Bond LC, prime and Bond and Bisco one Step. Statistically no difference was observed in dye penetration scores for the different bonding systems. Thermal stresses had some influence on marginal seal but this was product and tissue specific.

O Tulunoglu et al (1999)[45] did an in-vitro investigation of the effect of use of three dentin bonding agents on microleakage and shear bond strength of a fissure sealant bonded to either dry or wet enamels of primary teeth. They tested Scotchbond MP plus, Syntac, Optibond Dual cure adhesive systems. Fresh human saliva was used for contamination and assessed for dye penetration for microleakage. The results revealed that the use of an enamel-dentin bonding agent as an intermediary layer between the primary tooth and fissure sealant would be beneficial for increasing the bond strength and for decreasing the microleakage. They also concluded that using enamel dentine bonding agents under sealant in moisture contaminated conditions give better results rather than applying sealant alone on non-contaminated enamel.

Fritz et al(1999)[8] noted that rubber dam is commonly applied in fewer than 10% of restorative treatments. Manufacturers of compomer restoratives were the first to delete the requirement of the application of rubber dam and since then, an increasing number of material instruction sheets for enamel and dentin adhesives mention that the field of operation may be kept dry by means of cotton rolls. This change of opinion seems to coincide with the broad acceptance of modern so called single bottle adhesives. Many One step or Single bottle dentin adhesives have been recently introduced. They combine the functions of primer and adhesive components of the conventional three step (etchant, primer and bonding agent) adhesive system.

They studied the effect of salivary contamination of enamel and dentin on bonding efficacy of a single bottle adhesive . It was found that single bottle adhesive system is relatively insensitive to salivary contamination provided that the contamination occurs prior to light curing of the adhesive and is carefully rinsed and blot dried. Salivary contact after adhesive curing should be avoided.

Kalla (1999)[46] examined and compared the effect of saliva contamination on the resin micro morphological adaptation of single bottle adhesives. The four adhesives formed hybrid layer with resin tags penetration into the dentin. Prime and Bond 2.1 showed usually funnel shaped resin tags. The authors concluded that saliva contamination did not prevent hybrid layer formation and resin penetration into the dentinal tubules

Kalla et al (1999)[47] explored the topography of the interface of composite resin, bonded with single bottle adhesives and enamel under salivary contaminated conditions. Prime and Bond 2.1, One Step , Tenure quick, Syntac components were evaluated in this in-vitro study on human molars . Saliva contamination either washed or unwashed did not affect the resin tags formation except for Syntac Single component with contaminated unwashed enamel. The authors suggested that saliva contamination did not affect the resin tags formation of Prime and Bond 2.1, One Step and Tenure Quick.

Raphael Pilo et al (1999)[48] in an in-vitro study compared the ability of several recently introduced single-bottle adhesives to their preceding multiple-step dentin bonding agents in reducing microleakage around class V composite restorations. The tested bonding agents are Optibond FL and Solobond, All Bond 2 and One-Step and Scotchbond MP and Single bond. The authors concluded that single-bottle adhesive systems performed equally in terms of microleakage compared with multistep adhesives .

Schmitt et al (1999)[49] conducted an in-vitro study to compare the microleakage of fourth generation filled and unfilled adhesive resin systems with fifth generation filled and unfilled adhesive resin systems in both primary and permanent teeth. No significant difference in microleakage was observed between fourth and fifth generation adhesive systems, whether filled or unfilled, or applied on primary or permanent teeth. The authors concluded that single-bottle, fifth generation adhesive resin systems permit easier application with the same effectiveness as the two-bottle , fourth generation systems.

T Dietrich et al (2000)[50] et al investigated the influence of dentin conditioning and contamination on the marginal adaptation of class II sandwich restorations. The three different pretreatments compared were total etch, selective etch and dentin contamination with saliva and blood prior to primer/adhesive application. They concluded that sandwich restorations might be less sensitive to contamination with saliva and blood during the bonding procedure.

Amaral et al (2002)[51] evaluated the marginal microleakage and the extent of polymerization in class II resin composite restorations prepared with two restorative techniques (bulk placement, increment placement) and two polymerization systems (conventional, soft-start).The authors concluded that the incremental technique resulted in less microleakage . The soft-start system provided adequate polymerization but could not improve marginal sealing.

A.A. El- Housseiny et al (2002)[52] did an in-vivo study to compare the ability of a single bond adhesive to its preceding multistep dentin bonding agent in reducing microleakage around class V composite resin in primary teeth. The adhesive systems tested were Scotch bond MP and Single bond . The authors concluded that single-bottle adhesive performed equally well in terms of micro leakage, compared with multistep adhesive. None of the adhesive systems was able to completely prevent leakage of the class V restorations. Additional preventive measures should be implemented whenever using composite resin in children.

Thomas Pioch et al (2002)[53] investigated the degree of nanoleakge in Class V preparations restored with three bonding agents using wet and dry bonding. The teeth were stored in 1 % rhodamine solution for nanoleakage studies and evaluated using confocal laser Scanning Microscope. The bonding systems used were Scotch bond 1, prime and Bond NT and Gluma CPS. Scotch bond multipurpose and Prime and bond NT showed lower bond strength with dry bonding , because of the ethanol and acetone based solvents, which is highly versatile. Gluma CPS showed increased bonding because of water based solvent. In this study they found that wet bonding increases the marginal seal when acetone or ethanol based primers were used. There was no significant difference in nanoleakage using Gluma CPS with dry and wet bonding. The authors concluded that dentin dryness has an influence on nanoleakage depending upon the nature of individual bonding agents used.

M. Miyazaki et al (2002)[54] evaluated the adhesion of single application bonding systems to bovine enamel and dentin. The bonding agents used were Reactimer bond, One –up bond F, AQ bond and Prompt L Pop. The Adhesive One application bonding systems is a hydrophilic solution that is extremely effective in wetting the tooth surface. The etching effect of these systems is related to the acidic monomers that may interact with the mineral component of tooth surface and enhance monomer penetration. Penetration of acidic monomers in to tooth surface created resin tags for enamel and hybrid layer for dentin. They concluded that these single application adhesives reduced the number of application methods, thereby reducing the errors during procedural sequence and increasing the bond strength.

Yazici et al (2002)[55] determined the microleakage of current generation dentin bonding systems in Class II composite restorations. They concluded that most of the current generation dentin bonding systems were able to eliminate microleakage completely in the occlusal walls, but they exhibited significant differences in leakage in the gingival walls.

Pontes et al (2002)[56] compared the microleakage of new all in one adhesive systems on enamel and dentin margins with that of a conventional total etch system. The tested adhesive systems were Etch and prime, Prompt L Pop and Prime and Bond 2.1 . They concluded that on enamel margins, there was significantly less microleakage in the Prompt L Pop group than in teeth treated with Prime& Bond 2.1. On dentin margins , no statistically significant differences were found among the groups.

Martin et al (2002)[57] evaluated the in-vitro microleakage of six dentin adhesives systems, regarding the influence of time and thermocycling. The authors concluded that the adhesion to enamel was not significantly affected by the passage of time or by thermocycling, regardless of the adhesive used.

RM Gagliardi et al (2002)[58] evaluated microleakage in-vitro using different bonding agents. The specimens were stained with 50% silver nitrate. They concluded that Self etching agents could provide similar marginal seal to one bottle adhesives.

Dura fill Bond had significantly more microleakage compared to all other adhesives. None of the materials used eliminated microleakage.

Duangthip et al (2003)[59] conducted an in-vitro study to evaluate the microleakage and penetration ability of sealing materials applied under different conditions of contamination. The surface treatment groups were no moisture and no saliva contamination, moisture contamination, dried saliva contamination, wet saliva contamination. Microleakage , penetration ability and fissure types were examined . They concluded that when there is no saliva contamination, Concise showed less microleakage than the Optibond system. When saliva contamination is apparent, the use of bonding agent as a single sealing material an as an intermediary layer between enamel and sealant is beneficial for decreasing microleakage and increasing the penetration ability of sealants.

Susanne Szep et al (2003)[60] conducted an in-vitro study to examine the etching effects of phosphoric acid versus a combination of phosphoric and hydrofluoric acid by evaluation of microleakage in a composite restoration bonded with different dentin adhesives systems. The authors concluded that total-etch water based and acetone based bonding agents with a combination of phosphoric acid and hydrofluoric acid led to significant reduction in dye penetration compared to phophoric acid conditioning only. Ethanol based dentin bonding agents were not significantly influenced by the type of conditioner used.

LW Shook et al (2003)[61] determined whether the surface roughness of the internal walls of a Class V resin composite preparation , using a carbide bur, a medium grit diamond bur and a fine grit diamond bur, affected the degree of microleakage of the restoration. No statistically significant differences in microleakage across bur types was found. They also reported marginal leakage at the dentinal surface was significantly more than enamel margins for all bur types.

E. Koliniotou- Koumpia et al (2004)[62] investigated an in-vivo evaluation of microleakage in Class V composite resin restorations with total etch versus self-etching adhesives. The authors concluded the total-etch adhesives revealed significantly less microleakage than the self-etching adhesive systems.

Atash et al (2004)[63] conducted an in-vitro study evaluating the sealing ability of different types of restorative adhesive combinations on deciduous molars. They concluded that the two single step self etch adhesives analyzed in this study presented lower microleakage scores when compared to a total etch system. Different adhesive systems can affect the sealing ability of Class V restorations.

Santini et al (2004)[64] conducted an in-vitro study to evaluate microleakage around Class V resin composite restoration with different cavity configurations, bonded with one of seven self-etching materials or with an adhesive using the total etch technique. They concluded that cavity configuration did not affect microleakage either with self etching or the total etch technique.

Pinar et al (2005)[65] assessed the effect of a single bottle bonding agent on sealant success after 3,6,12 and 24 months. They observed the use of a bonding agent as an intermediary layer between enamel and sealant did not affect sealant success during a 24 month.

Tar C AW et al (2005)[66] conducted an in-vivo investigation to compare the clinical performance of two commercial single-bottle adhesives and a two bottle adhesives for restoration of non carious lesions. They tested Scotch bond MP, single bond and One –coat bond. The authors assessed restorations in terms of retention, marginal integrity, margin discoloration and air sensitivity at baseline, six months, one year, two years and three years after placement. They concluded all three adhesives performed with acceptable with small differences between the one and two-bottle adhesive systems and between the various solvents. They suggested that the type of solvent may not be a major factor in retention of Class V restorations in non carious lesions. Both single bottle and conventional two bottle adhesives performed acceptably.

Kallenos et al (2005)[67] did an in-vitro evaluation of microleakage of newer generations of dentinal bonding systems of Class I restorations filled with the same resin based composites. They tested among fifth, sixth and seventh generation dentin bonding agents and methylene blue was used for microleakage assessment. The results revealed that the fifth generation bonding system outperformed the sixth and seventh generation bonding systems.

MATERIALS AND METHODS

MATERIALS AND METHODS

This in- vitro study was conducted in the Department of Pedodontics and Preventive dentistry, Saveetha Dental College, Chennai.

One hundred fifty extracted sound premolars free of caries, fluorosis, fissure sealants and restorations were selected. The teeth were cleaned from tissue remnants and stored in distilled water with thymol until they were used. Buccal butt-joint Class V cavities (2 mm in height, 4 mm in the mesiodistal direction and 2 mm in depth) were prepared with a No. 330 tungsten carbide bur in an air turbine with copious water spray cooling. A new bur was employed on every fourth cavity to avoid excessive heating.

The teeth were randomly numbered from 1 to 150 and assigned to 15 treatment groups with 10 teeth each. The roots were embedded in self curing resin. The treatment groups were defined by the combination of five adhesives and three surface conditions.

The five adhesive systems used were as follows:

1. Adper single bond (3M ESPE)

- BisGMA, HEMA, dimethacrylate, polyalkenoic, acid copolymer, ethanol and water, photoinitiators

2. Gluma Comfort bond (HERAEUS KULZER)

- HEMA,, Methacrylate, ethanol, photoinitiators, maleic acid

3. Excite Bond (VIVADENT)

- Methacrylate, ethanol and water, phosphonic acid acrylate, photoinitiators

4. Syntac bond (VIVADENT)

Syntac Primer - polyethylene glycol dimethacrylate, maleic acid, ketone

Syntac adhesive - polyethylene glycol dimethacrylate, glutaraldehyde

5. Adper Prompt L Pop (3M ESPE)

Liqiud 1 (red blister) – methacrylate phosphoric esters Bis-GMA, Stabilizers Initiators based on camphoroquinone

Liquid 2 (yellow blister) - stabilizers, water HEMA, polyalkenoic acid

The three surface conditions described are as follows:

1. No saliva contamination
2. Saliva contamination, left undisturbed
3. Saliva contamination and rinsed off

All procedures were performed under room temperature.

1. Etch using a 37% phosphoric acid gel (Total Etch, 3M) for 15 seconds.

2. Rinse for 30 seconds with an air-water syringe

3. Dry with oil-free compressed air for15 seconds.

4. Variable surface conditions:

A. No Saliva Contamination: To serve as a control ,the procedures for groups 1,4 and 7 ,10 and 13 were performed .

B. **Saliva contamination and left undisturbed (Groups 2,5,8, 11 and 14):** Fresh whole saliva was collected daily from the examiner and syringed onto etched enamel surfaces. This was left undisturbed for 10 seconds followed by the excess saliva being removed using cotton pellets .*This corresponds to contamination being unnoticed in the clinical situation.*

C. Saliva contamination and rinsed off (Groups 3,6 ,9, 12 and 15): Similar to second surface treatment except that the saliva was rinsed with a water stream from an air-water syringe for 20 seconds. Excess water was removed using cotton pellets. *This corresponds to contamination being noticed at the time of occurrence and being washed as soon as possible (e.g. after 20 seconds)*

5. Adhesive Application

➢ **Adper Single Bond , Gluma Comfort bond, Excite Bond**

- Immediately after blotting, apply 2-3 consecutive coats for 15 seconds with gentle agitation using a fully saturated applicator. Gently air dry for five seconds to evaporate solvents. Light cure for 10 seconds (Q Lux, 3M light curing unit)

- **Syntac Bond**

Syntac Primer requires a contact time of 15 seconds on the dentin. Excess is then removed and dried with air syringe. Syntac adhesive is applied and left for 10 seconds and dried thoroughly with blown air. Light cure for 20 seconds.

- **Prompt L Pop**

Prompt L Pop is applied to the entire surface and rubbed for 15 seconds. It is then air blown to disperse the material to thin film and light cured for 10 seconds.

6. Composite resin placement (Z 250, Universal Dentine Shade) placed in two increments and light cured for 20 seconds for each increment.

THERMOCYCLING AND DYE PENETRATION

Following composite placement, the teeth were thermocycled in water for 500 cycles between 5^0C +-2 ^0C and 55 ^0C $^{+-}$ 2^0C with a dwell time of 30 seconds. The surfaces of the teeth were coated with nail varnish, leaving approximately 1 mm uncovered around the restoration. The coated teeth were immersed in 0.5 % methylene blue in an incubator at 37 degrees Celsius for 48 hours to allow dye penetration into possible gaps between the tooth substance and the restoration.

MICROSCOPIC EXAMINATION

For further examination, the teeth were rinsed thoroughly with tap water. The teeth were sectioned bucco-lingually into two fragments with a diamond disc. Sections were evaluated for microleakage by a reflected light binocular stereomicroscope (Carl Zeius, Germany) at 40X magnification. The most severe degree of dye penetration for each tooth was always recorded. Dye penetration at the composite/tooth interface was scored for both occlusal wall and cervical margins on a nonparametric scale from 0 to 3.

SCORING SYSTEM FOR MICROLEAKAGE

Microleakage Score	**Degree of Dye Penetration**
0	No dye penetration
1	Dye penetration less than half way to the axial wall
2	Dye penetration greater than halfway to the axial wall
3	Dye penetration along the axial wall

PROCEDURAL SEQUENCE

150 EXTRACTED TEETH

↓

CLASS V CAVITY PREPARATION

↓

RANDOMLY DIVIDED INTO 15 GROUPS

5 BONDING AGENTS

- **ADPER, GLUMA,EXCITE, SYNTAC, PROMPT L POP**

3 TREATMENT CONDITIONS

- **uncontaminated**
- **saliva contamination, air dried**
- **saliva contamination, water rinsed**

↓

TEETH SPECIMENS COATED WITH NAIL VARNISH

↓

SPECIMENS IMMERSED IN METHYLENE BLUE DYE FOR 48 HOURS

↓

SPECIMENS SECTIONED BUCCO-LINGUALLY

↓

VIEWED UNDER STEREO MICROSOPE AT 40X MAGNIFICATION

TOOTH SAMPLES STORED IN SALINE

T OOTH SAMPLES ARRANGED IN GROUPS

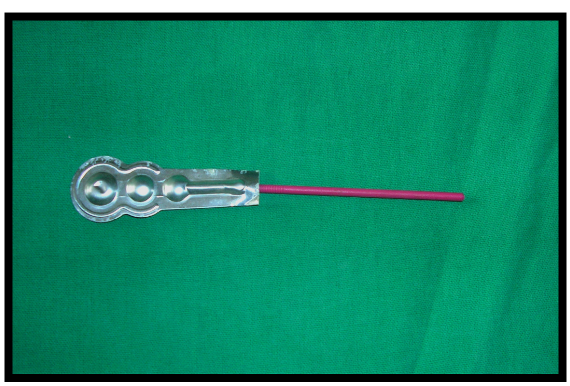
ARMAMENTARIUM

ADPER SINGLE BOND

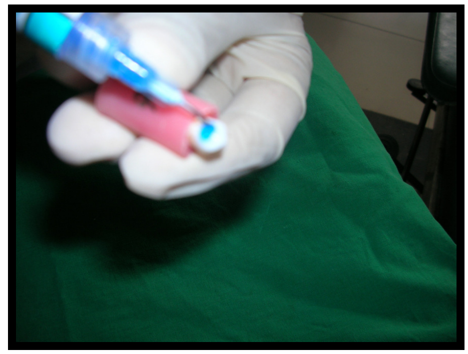
EXCITE BOND

GLUMA BOND

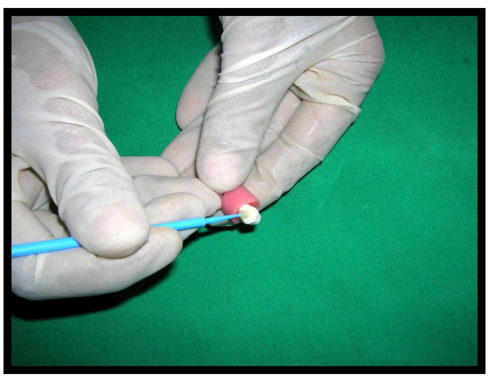
SYNTAC TWO BOTTLE ADHESIVE

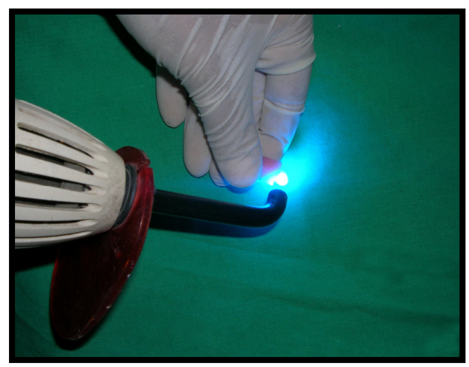


PROMPT L POP ADHESIVE

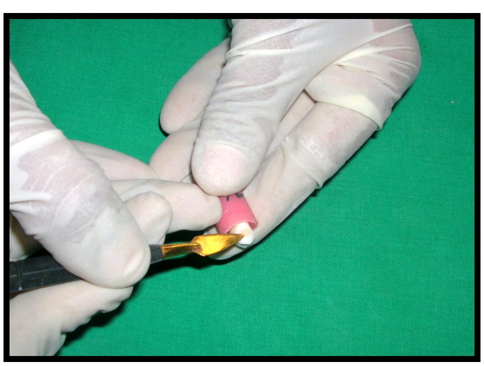


CAVITY PREPARATION **ACID ETCH STEP**

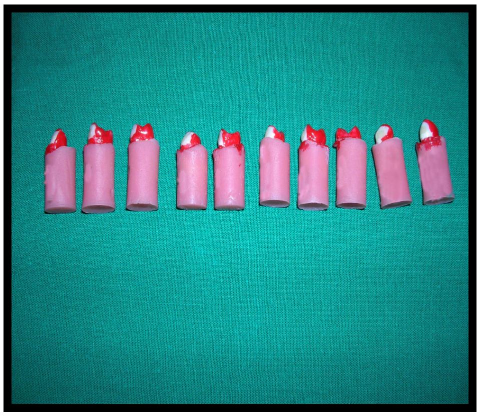




ADHESIVE APPLICATION **ADHESIVE CURING**

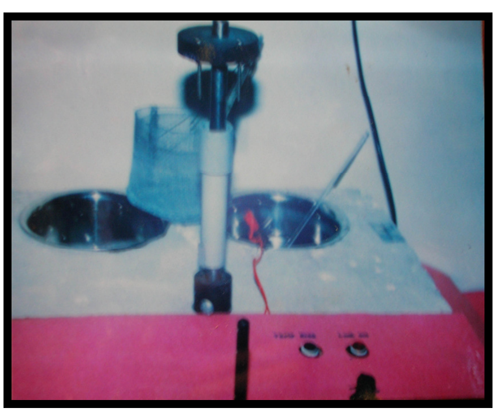


COMPOSITE RESTORATION **COMPOSITE CURING**



SPECIMENS COATED WITH VARNISH

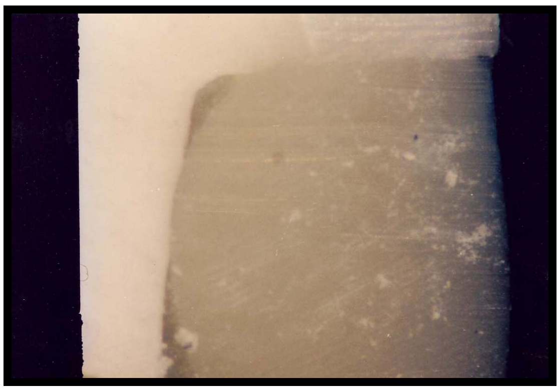
SPECIMENS INCUBATED IN METHYLENE BLUE



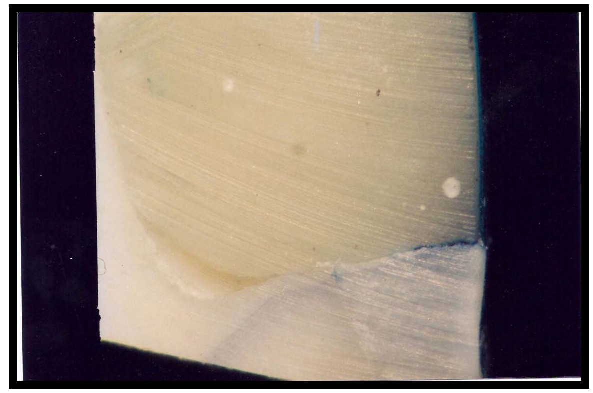
THERMOCYCLING CHAMBER

STEREOMICROSCOPE

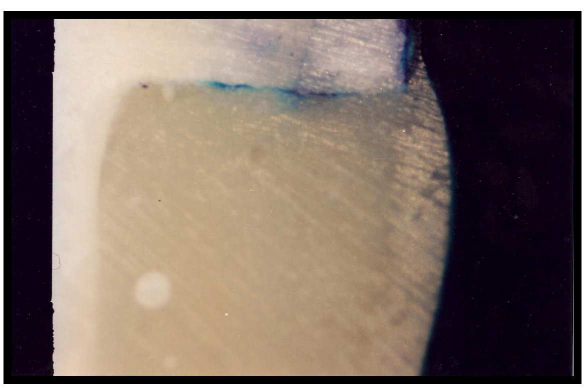
SPECIMENS VIEWED UNDER STEREOMICRISCOPE



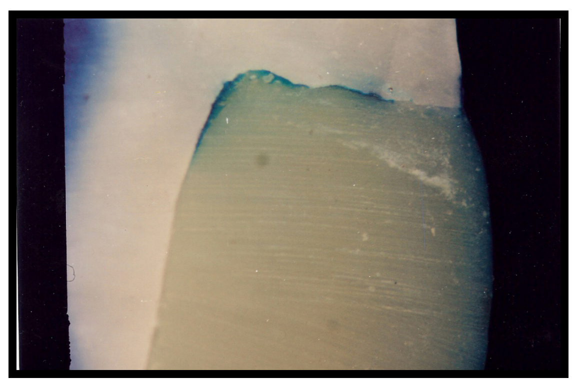
SCORE 0



SCORE 1



SCORE 2



SCORE 3

RESULTS

RESULTS

TABLE I shows the number of teeth samples showing the microleakage score for each subgroups of the five different current generation bonding agents.

The table clearly shows that the single bottle adhesives Adper, Gluma and Excite displaying teeth samples with minimal microleakage score followed by Syntac and lastly by Prompt L Pop. The maximum number of teeth samples for score 0 (n=3) was seen in the Adper and Excite adhesive systems whereas Prompt L Pop displayed the maximum teeth samples with Score 3 (n=7).

TABLE 1 : TABLE SHOWING THE NUMBER OF SAMPLES SHOWING MICROLEAKAGE SCORE FOR EACH SUBGROUPS OF THE FIVE BONDING AGENTS

		ADPER			GLUMA			EXCITE			SYNTAC			PROMPT L POP		
MICROLEAKAGE	GROUP	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV	XV
	SCORE O	1	2	3	2	1	2	2	2	3	1	0	0	1	0	0
	SCORE 1	4	4	3	3	3	4	3	2	4	3	3	1	3	3	0
	SCORE 2	3	3	2	4	4	3	3	3	1	4	5	4	4	2	3
	SCORE 3	2	1	2	1	2	1	2	3	2	2	2	5	2	5	7

Table 2 shows the comparison of mean values between five different current generation adhesives.

Of the five current generation adhesives that were tested, the single bottle adhesives namely Adper, Gluma and Excite showed very good bonding efficiency and minimal microleakage with no statistically significant differences between each of them.

The mean scores comparison showed statistically significant differences between the single bottle bonding agents (Adper Single bond, Gluma and Excite) and Syntac, Prompt L Pop ($p=0.003$).

The Syntac and Prompt l Pop adhesives did not show good bonding efficiency when compared to the single bottle adhesives with the latter performing the worst.

TABLE 2: COMPARISON OF MEAN VALUES BETWEEN DIFFERENT BONDING AGENTS

GROUP	SCORE Mean +_ SD	P VALUE	Significant Groups at 5 % Level
ADPER SINGLE BOND	1.4 +- 1.0		SYNTAC, PROMPT L POP
GLUMA	1.5 +- 0.9		SYNTAC, PROMPT L POP
EXCITE	1.5 +- 1.1		SYNTAC, PROMPT L POP
SYNTAC	2.0 +- 0.8		
PROMPT L POP	2.2 +- 0.9	0.003	

- **KRUSKAL-WALLIS ONE WAY ANOVA TEST was used to calculate the p- value**
- **MANN- WHITNEY U TEST was employed to identify the significant groups at 5 % level**

GRAPH A: COMPARISON OF MEAN VALUES BETWEEN DIFFERENT BONDING AGENTS

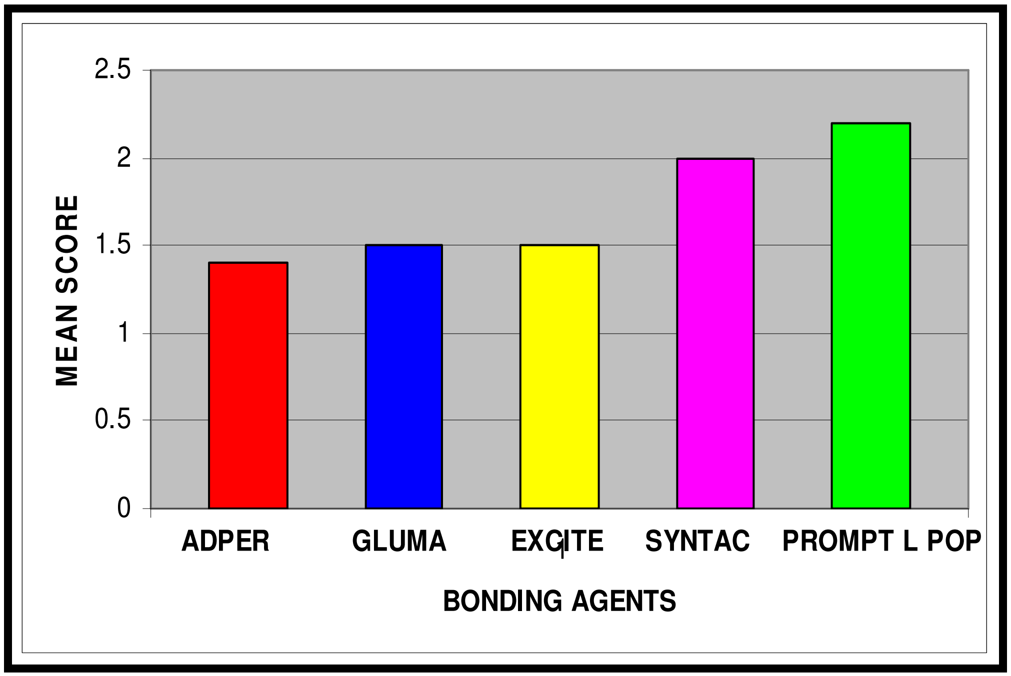


Table 3 shows the Mean Standard deviation and test of significance of mean values between different subgroups for each bonding agent. For Adper Single bonding agent, the Mean score was lowest in group II (1.3+_0.9) and in group III (1.3 +_1.2) and the highest was in group I (1.6+_1.0). However, there was no statistically significant difference in mean scores among the three groups (p= 0.74)

For Gluma bonding agent, the Mean score was lowest in group VI (1.3 +_0.9) followed by group IV (1.4+_1.0) with group V showing highest score (1.7 +_0.9). However, there was no statistically significant difference in mean scores among the three groups (p=0.61).

For Excite bonding agent, the Mean score was lowest in group IX (1.2 +_1.1) followed by group VII (1.5+_ 1.1) with group VIII showing highest score (1.7 +_0.9). However, there was no statistically significant difference in mean scores among the three groups (p=0.59).

For Syntac bonding agent, the Mean score was lowest in group X (1.7 +_0.9) followed by group XI (1.9+_0.7) with group XII showing highest score (2.4+_0.7). However, there was no statistically significant difference in mean scores among the three groups (p=0.16).

For Prompt L Pop bonding agent, the Mean score was lowest in group XIII (1.7 +_0.9) with highest scores seen by groups XIV (2.2 +_ 0.9) and XV (2.7 +_0.5). Results showed that there was statistically significant difference in mean scores between group XIII and group XV (p = 0.046) suggesting that it performed poorly in the presence of saliva.

TABLE 3 :' MEAN STANDARD DEVIATION AND TEST OF SIGNIFICANCE OF MEAN VALUES BETWEEN SUBGROUPS FOR EACH BONDING AGENT

BONDING AGENT	SUB GROUP	SCORE MEAN +_ S.D	p VALUE	Significant groups at 5 % level
ADPER BOND	I II III	1.6 +_ 1.0 1.3 +_ 0.9 1.3 +_ 1.2	0.74	NIL
GLUMA	IV V VI	1.4 +_ 1.0 1.7 +_ 0.9 1.3 +_ 0.9	0.61	NIL
EXCITE	VII VIII IX	1.5 +_ 1.1 1.7 +_ 1.2 1.2 +_ 1.1	0.59	NIL
SYNTAC	X XI XII	1.7 +_ 0.9 1.9 +_ 0.7 2.4 +_ 0.7	0.16	NIL
PROMPT L POP	XIII XIV XV	1.7 +_ 0.9 2.2 +_ 0.9 2.7 +_ 0.5	0.046	XV Vs XIII

- **KRUSKAL-WALLIS ONE WAY ANOVA TEST was used to calculate the p- value**
- **MANN- WHITNEY U TEST was employed to identify the significant groups at 5 % level**

GRAPH B: MEAN STANDARD DEVIATION AND TEST OF SIGNIFICANCE OF MEAN VALUES BETWEEN SUBGROUPS FOR EACH BONDING AGENT

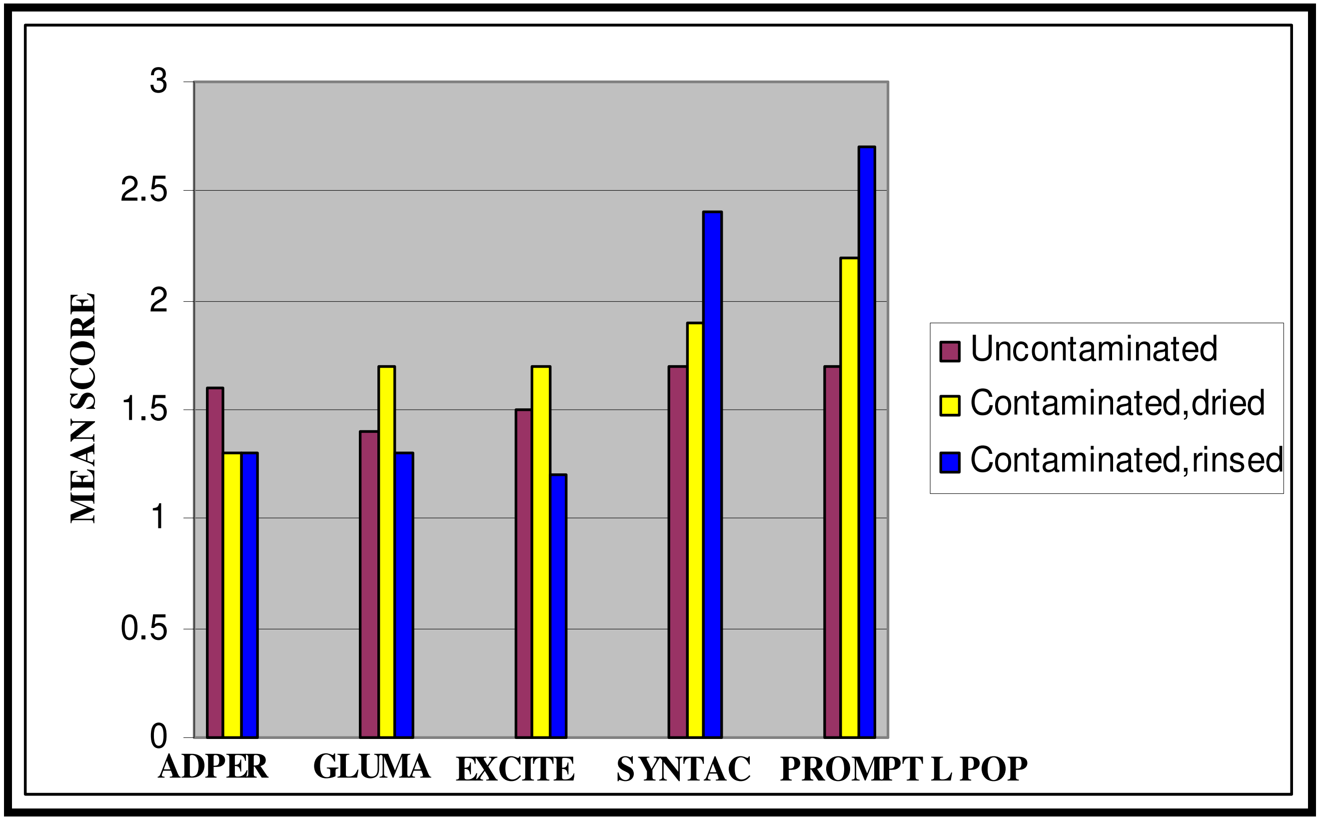


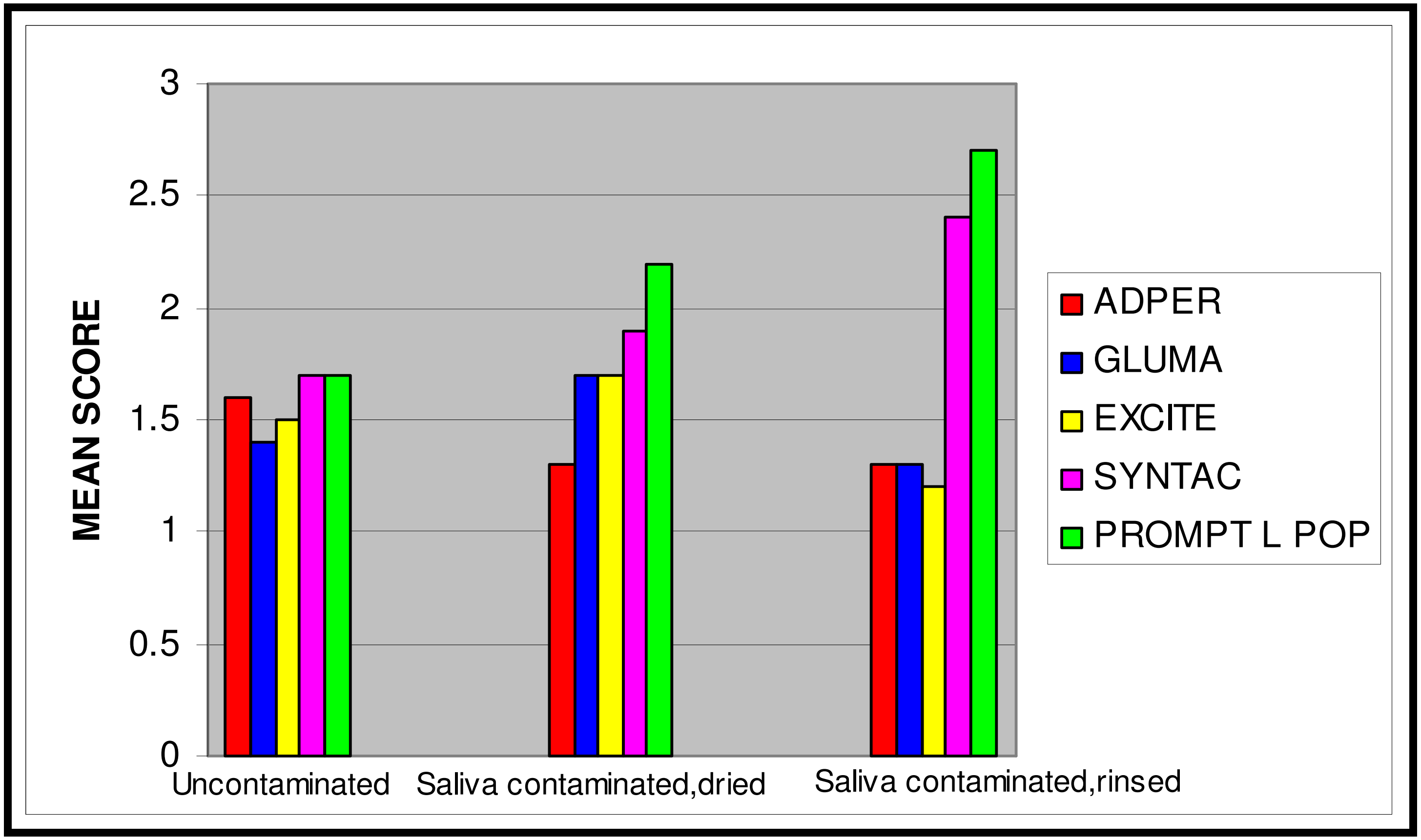
Table 4 shows Comparison Of Mean Scores Between Different Bonding Agents For Each Subgroup. In the uncontaminated and saliva contamination and blot dried groups , there was statistically no significant differences between the five adhesives tested. But in the saliva contamination and water rinsed group there was statistically significant difference (p=0.002) between the single bottle adhesives tested (Group 3,6,9) and Syntac (Group 12) and Prompt L Pop (Group 15) with the single bottle adhesives showing good bonding efficacy than the latter two adhesives.

TABLE 4: COMPARISON OF MEAN SCORES BETWEEN DIFFERENT BONDING AGENTS FOR EACH SUBGROUP

SUBGROUP	BONDING AGENT	SCORE MEAN+_ SD	P VALUE	Significant groups at 5% level
UNCONTAMINATED GROUP	ADPER GLUMA EXCITE SYNTAC PROMPT L POP	1.6 +_ 1.0 1.4 +_ 1.0 1.5 +_ 1.1 1.7 +_ 0.9 1.7 +_ 0.9	0.95	NIL
SALIVA CONTAMINATED BLOT DRIED	ADPER GLUMA EXCITE SYNTAC PROMPT L POP	1.3 +_ 0.9 1.7 +_ 0.9 1.7 +_ 1.2 1.9 +_ 0.7 2.2 +_ 0.9	0.35	NIL
SALIVA CONTAMINATED WATER RINSED	ADPER GLUMA EXCITE SYNTAC PROMPT L POP	1.3 +_ 1.2 1.3 +_ 0.9 1.2 +_ 1.1 2.4 +_ 0.7 2.7 +_ 0.5	0.002	Syntac, Prompt l pop Syntac, Prompt l pop Syntac, Prompt l pop

- **KRUSKAL-WALLIS ONE WAY ANOVA TEST was used to calculate the p- value**
- **MANN- WHITNEY U TEST was employed to identify the significant groups at 5 % level**

GRAPH C: COMPARISON OF MEAN SCORES BETWEEN DIFFERENT BONDING AGENTS FOR EACH SUBGROUP



DISCUSSION

DISCUSSION

Bonding is the attachment of one substance to another. A Bonding agent can then be defined as a material that when applied to surfaces of substances, can join them together and resist separation **(Kinloch 1987)**[68]. In the case of enamel bonding, a bi-functional bonding agent is attached by mechanical interlocking into the irregularities of the etched substrate surface which copolymerizes by carbon-carbon double bonds with the matrix of the subsequently applied composite resin. A specific kind of bonding is adhesion, which involves chemical attraction on the molecular level. A combination of both micromechanical and chemical bonding is likely to occur when dentin is involved **(Bowen et al 1982)**[69]

Over the past three decades many different bonding systems were evolved to bond composite resin to dentin. The common approach was the use of bi-functional molecule, which contained a hydrophilic group designed to bond to dentinal calcium or collagen and a hydrophobic group which would bond to resin.

The fifth generation adhesives are also known as single bottle adhesive or total etch systems. In these systems, the entire priming and bonding sequence involves a single liquid in a single bottle. These systems also depend upon hybrid zone formation in dentin. The major advantage of these systems, by far, is their simplicity of use. These systems contained elastomeric dimethacrylate resin, PENTA.[70,71]

The latest bonding agents (sixth and seventh generation) eliminate the need for etching with phosphoric acid by the use of an acidic primer. The sixth generation-Type I have components that are applied separately to the tooth. The Type II are first mixed and then applied. The seventh generation bonding agents are self etching adhesives that require no mixing.[72]

Salivary contamination is a potential problem during the etching procedure, especially in view of the fact that rubber dam is not possible in all clinical situations. Rubberdam may not be placed because of access limitations, a newly erupting tooth, an uncooperative patient or the unwillingness of the operator.[4] Rubber dam application is generally not easy with children without local anesthesia. Cotton roll isolation makes it a practical necessity that an assistant be involved to provide a four handed dentistry. Even with cotton rolls in place, it is easy for a child to contaminate the tooth while swallowing or with tongue movement[73]. The traditional approach for such contamination was re-etching the enamel.[8] Etching the enamel surface with 30-40% phosphoric acid removes approximately 1.4mm of surface enamel. Re-etching the enamel will result in a further reduction in the fluoride concentration in the surface enamel and may make the tooth surface more susceptible to caries attack.[5]

To simulate clinical situation of salivary contamination , fresh human saliva was collected from a single individual . According to **Silverstone et al(1985)[1], Brien et al(1987)[6], Hitt et al(1992)[4]** fresh human saliva is an acceptable material in testing saliva contamination.

In this study , an in vitro study model was chosen to :

1. Standardize the model
2. Obtain "ideal" adhesion conditions
3. Allow thermocycling , simulating stress caused by thermal variations.[73]

Microleakage at the tooth/restoration interface is considered to be a major factor influencing the longevity of dental restorations. It may lead to staining of the restorations hastening the breakdown at the marginal areas of the restorations, recurrent caries at the tooth/restoration interface, hypersensitivity of restored teeth and the development of pulpal pathology.

Clinicians and researchers use microleakage as a measure for assessing the performance of restorative materials in the oral environment. Hence in this study it was decided to use this technique for evaluating the performance of the current generation bonding agents under saliva contamination.

El Kalla et al (1999)[46] hypothesized that the potential of the "single bottle" bonding agents to bond even when applied after saliva contamination and without re etching was due to the presence of acetone or ethanol, which may displace or diffuse through a saliva film to reach the underlying hydroxyapatite or collagen as a condition for firm bonding after polymerization. Hence we tested for the commonly used three "single bottle" bonding agents with known composition. Fourth generation (Syntac) and sixth generation (Prompt L Pop) were added to investigate the microleakage behavior of the current generation dentin bonding agents under saliva contamination.

Legler et al (1989)[75] demonstrated that reduction in duration of acid etching did not have an adverse effect on the bond strength of resin. Accordingly the specimens in this study were subjected to acid etching for 15 seconds.

Bates et al (1982)[76] showed that an etched enamel surface should be washed for atleast 15 seconds to remove the reaction products. Hence after acid etching the tooth specimens were rinsed for 15 seconds to remove any reaction products after acid etching.

After rinsing, the specimens were air dried with oil-free compressed air for 15 seconds .

The tooth specimens were divided for five adhesives to be tested with three subgroups according to surface condition to be treated with. The surface condition treated is similar to one employed by **El Kalla (1999)**[46]**.** The first surface condition corresponds to the normally uncontaminated surface in the clinic. The second surface condition was saliva contamination left undisturbed for 20 seconds and excess removed by cotton pellets. This corresponds to saliva contamination being unnoticed in the clinical condition. The third surface condition was after salivary contamination for 20 seconds, it was rinsed for 20 seconds. The excess water was removed by cotton pellets before adhesive application. This corresponds to saliva contamination being noticed at the time of occurrence and being washed as soon as possible.

After adhesive curing, the composite was placed in increments and light cured for 40 seconds for each increment. This was in accordance to the conclusion noted by **Amaral et al(2002)**[51] that incremental restorative composite technique resulted in less microleakage than did the bulk placement technique.

Many laboratory techniques have been developed to study marginal permeability at the interface between tooth and restoration .These include the use of dyes , radioactive isotopes, air pressure, bacteria, neutron activation analysis, and artificial caries techniques. The results of these studies emphasize that margins of restorations are not fixed but “dynamic” microcrevices which maintain a busy traffic of ions and molecules.[73]

Dye penetration measured on sections of restored teeth is the most common technique for evaluation of microleakage at the tooth- restoration interface.[68] The use of organic dye as tracers is one of the oldest and most common methods of detecting leakage in vitro. In the present study microleakage has been detected by using 0.5% methylene blue dye.

Studies indicated that methylene blue was a superior tracer of microspaces , accessory canals and dentin tubules owing to its relatively low molecular weight. Thus methylene blue may serve as an indicator of leakage of microorganisms, large sized endotoxins as well as low molecular weight toxic agent.[73] The microleakage scoring system used in this study is similar to the one used by **AUJ Yap et al (1998)**[44] .

The results from this study while comparing the mean microleakage values between the five different current generation adhesives showed that the single bottle bonding agents (Adper Single bond, Gluma and Excite) displayed good bonding efficacy with minimal microleakage scores compared to Syntac and Prompt L Pop. There was statistically significant differences between the three single bottle adhesives and Syntac and Prompt L Pop (p=0.003) . These results were similar to the studies of **Kallenos et al (2005)**[67] and **Koumpia et al(2004)**[62]**.** The superior bonding efficiency of the single bottle adhesives was explained by **Kanca III (1992)**[24] that the acetone present in them facilitated the spreading of the primer over the water coated surface, chasing the water and carrying the primer resins deep into the dentinal surface. The poor performance of Prompt L Pop in this study can be corroborated by the findings of **Koumpia et al (2004)**[62] who said that the failure to use a separate acid etchant as a preliminary step on tooth enamel substrate resulted in insufficient bond strength and sealing ability with the enamel. In this water based Prompt L Pop system, water could compete with the water soluble primer components within the collagen network and prevent the collagen to be saturated with the primer resulting in more microleakage. There is a possibility that a lack of a separate primer may reduce the infiltration depth or the wettability of dentin adhesives, thereby reducing adhesion and sealing capacity. The results of this study did not correlate with the study by **Pontes et al(2002)**[56] which showed that Prompt

L Pop showed less microleakage score than the single bottle adhesives, confined only to the enamel margins. In their study bovine teeth were used as compared to human premolar teeth used in this study. This led to the variation in the results as the bovine teeth are larger in size and thickness, with greater surface area which could have determined the lower microleakage scores compared to this study.

Next comparative analysis was done to study the performance of these five different adhesives in different surface treatment conditions (uncontaminated, saliva contamination and blot dried, saliva contamination and water rinsed). With regard to salivary contamination, the three single bottle adhesives and Syntac displayed good bonding efficiency with no statistically significant differences among themselves. This is similar to results obtained by **El Kalla et al (1999)**[47]. They found that blot drying of saliva contaminated enamel was sufficient to establish the same high bond strength as mediated to uncontaminated enamel. They also suggested that saliva contamination did not prevent hybrid layer formation and resin penetration into the dentinal tubules. But **Pashley et al(1991)**[23] found contradicting results stating that salivary contamination lower the bond strength of resin enamel and dentin bonds. The results in our study showing the equally good performance of Syntac to single bottle adhesives is similar to the studies of **Bonilla Z Yu et al(1997)[42], Raphael Pilo et al(1999)[48] and Schmitt et al(1999)[49].** The bonding efficiency of Prompt L Pop in the presence of salivary contamination was once again found to be poor. This can again be explained by the reasons given by **Koumpia et al (2004)[62] .**

An inter group comparison of the performance of the five different adhesive systems in different surface treatment conditions(uncontaminated, saliva contamination and blot dried, saliva contamination and water rinsed) revealed that the single bottle adhesives performed equally well followed by Syntac with Prompt L Pop fairing the worst. The good bonding efficacy of the single bottle adhesives was explained by **Miyazaki et al(2002)[54]** that the reduced number of application steps eliminated the procedural errors that may occur during the single bottle adhesive application thus increasing the bond strength.

SUMMARY AND CONCLUSION

SUMMARY AND CONCLUSION

The aim of this study was to evaluate the effect of salivary contamination on microleakage of composites bonded onto human teeth with current generation adhesives. One hundred and fifty human premolars free of caries, fluorosis and restoration were randomly assigned to 15 treatment groups of 10 teeth each. The treatment groups were defined by the combination of 5 bonding agents & 3 surface conditions. Class V cavities were prepared on the buccal surfaces of the teeth. They were acid etched with 37% phosphoric acid gel for 15 seconds, water rinsed for 30 seconds and air dried for 15 seconds. The first surface treatment was an ideal no saliva contaminated surface acting as a control group. The second surface treatment was saliva contamination left undisturbed for 15 seconds and blot dried with cotton pellets. This corresponds to contamination being unnoticed in the clinical situation. The third surface treatment was saliva contamination and water rinsed. This corresponds to contamination being noticed at the time of occurrence and washed as soon as possible. Then composite restorations were placed in two increments and light cured for 20 seconds for each increment. The teeth samples were thermocycled, coated with nail varnish and immersed in methylene blue dye for 48 hours. The teeth specimens were sectioned bucco-lingually and assessed for microleakage using a scoring criteria of 0-3 by viewing under stereomicroscope at 40X magnification. Then the results obtained were statistically analyzed firstly to compare the bonding efficiency of the five current generation adhesives, secondly their efficacy under different surface treatment conditions and thirdly an inter group comparison for each of the adhesives in different surface treatment condition was carried out.

The conclusions that can be drawn from the present study are as follows

- Of the five current generation adhesives tested, the single bottle adhesives namely Adper, Gluma and Excite showed equally good performance with minimal microleakage scores compared to Syntac and Prompt L Pop.
- Of the five current generation adhesives that were tested, the single bottle adhesives namely Adper, Gluma and Excite showed very good bonding efficiency and minimal microleakage with no statistically significant differences between each of them.

- The Syntac and Prompt L Pop adhesives did not show good bonding efficiency when compared to the single bottle adhesives with the latter performing the worst.
- With regard to salivary contamination samples, the three single bottle adhesives performed the best(Group 3, 6 and 9) followed by Syntac(Group 12) .
- The bonding efficiency of Prompt L Pop (Group 15) in the presence of salivary contamination was once again found to be poor.
- An inter group comparison of the performance of the five different adhesive systems in different surface treatment conditions(uncontaminated, saliva contamination and blot dried, saliva contamination and water rinsed) revealed that the single bottle adhesives performed equally well followed by Syntac with Prompt L Pop faring the worst

While the outcome of the study clearly implies the superiority of the single bottle adhesive systems with regard to bonding efficiency and microleakage, further clinical research needs to be done on a large sample size.

BIBLIOGRAPHY

BIBLIOGRAPHY

1. **Leon M Silverstone, John Hicks and J Featherstone.** *Oral fluid contamination of etched enamel surfaces : a SEM study.* Journal of American Dental Association 1985, 110, 329-333.
2. **Robert J Fiegal, Janet Hitt, Christian Spliett.** *Retaining sealant on salivary contaminated enamel.* Journal of American Dental Association 1993, 124, 88-97.
3. **George Knight, Thomas G berry, Barghi**. *Effect of two methods of moisture control on marginal leakage between resin composite and etched enamel: A clinical study.* Int J. Prosthodontics 1993 , 475-479
4. **Janet C Hitt, Robert Fiegal.** *Use of a bonding agent to reduce sealant sensitivity to moisture contamination : an in vitro study.* Pediatric dentistry 1992,14, 41-46
5. **JA Safar, RD Davis, JD Overton.** *Effect of saliva contamination on the bond of dentin to resin modified GIC.* Operative Dentistry 1999, 24,351-357.

6. **Brien III, JA Retief, Bradley EL, Denys FR.** *Effect of saliva contamination and phosphoric acid composition on bond strength.* Dental materials 1987, 3, 296-302.

7. **N Barghi, GT Knight, TG Bery.** *Comparing two methods of moisture control in bonding to enamel: A clinical study.* Operative dentistry 1991, 16, 130-135.

8. **Ulrike B Fritz, WJ Finger, H Stear.** *Salivary contamination during bonding procedures with a one bottle adhesive system.* Quintensse International 1999, 29, 567-572.

9. **John M Powers, Werner J finger, Jianxiu Xie.** *Bonding of composite resin to contaminated human enamel and dentin.* J Prosthodontics 1995, 4, 28-32

10. **Edward J Switt, Jorge Perdiago, Harald O heymann, Andre V Ritter.** *Shear bond strength of one- bottle adhesives to moist enamel.* Journal Of Esthetic Dentistry 1999, 11(2), 103-107.

11. **Buonocore MG**. *A simple method of increasing the adhesion of acrylic filling materials to enamel surfaces.* Journal Of Dental Research 1955, 34, 849-853

12. **Robert E Braier, Perolof- Glantz.** *Characterization of oral invivo films formed on different types of solid surfaces.* Acta Odontologica Scandinavia 1978,36,289-301.

13. **Knud Dreyer Jorgensen, Kazuo Itoh.** *Composite wall-to-wall polymerization contraction in dentin cavities treated with various bonding agents.*Scandavian journal of dental research 1985,93,276-279.

14. **Thomas J Ballesteros, Edward Souke, Barry K Norling, Robert B Mathew.** *The influence of contamination on the bond strength of an etched resin bonded retainer.* Journal Of American Dental Association 1986,112, 359-364.

15. **W.S. Eakel.** *Effect of thermal cycling on fracture strength and microleakage in teeth restored with a bonded composite resin.*Dental materials 1986, 2, 114-117.

16. **Ingegred Mejare, Bertil Mejare and Stig Edwardson.** *Effect of a tight seal on survival of bacteria in saliva contaminated cavities filled with composite resin.*Endodontic Traumatology 1987, 3, 6-9.

17. **Gary A Crim, Franklin Garcia – Godoy.** *Microleakage- the effect of storage and cycling duration.* Journal of Prosthetic Dentistry , 1987, 57,574-576.

18. **D. R. Powis, HJ Prosser.** *Long term monitoring of microleakage of composites. Part I – radiochemical Diffusion technique.* Journal Of Prosthetic Dentistry, 1988, 60, 304-307.

19. **C. Shortall.** *Long term monitoring of microleakage of composites. Part Ii- Scanning electron microscopic examination of replica patterns of composite tags.* Journal Of Prosthetic dentistry, 1988, 60, 451-458.

20. **B Tortenson, A Oden.** *Marginal adaptation of posterior resins- effect of dentin bonding agents and hygroscopic expansion.* Dental materials 1989, 5, 122-126.

21. **Hansen EK, Munksgaard EC.** *Saliva contamination effects of dentin bonding agents.* Dental materials 1989, 5, 329-333.

22. **Gary A Crim.** *Influence of bonding agents and composites on microleakage.*

    Journal Of Prosthetic dentistry1989,61,571-574.

23. **David H Pashley.** *Dentin Bonding- Overview of the substrate and respective adhesive material.* Journal of Esthetic Dentistry 1991, 3(2), 46-50.

24. **John Kanca III.** *Resin bonding t wet substrate- II, Bonding to enamel.*

    Quintensse International 1992, 23, 625-627.

25. **John Kanca III.** *Resin bonding to wet substrate- I , Bonding to dentin.* Quintensse International 1992, 23, 39-41.

26. **Vassiliakis N, Arnebrandt T, Glantz PO.** *Adsorption of whole saliva on to hydrophilic and hydrophobic solid surfaces : influence of concentration, ionic strength and pH.* Scand Journal of Dental Research 1992,100, 346-353.

27. **B Van Meerbeek , P Lambrechts.** *Factors affecting adhesion to mineralised tissues .* Operative dentistry 1992, Supplement 5 , 112-124

28. **Wendt SL,Moinnes PM, Dickinson GL.** *The effect of thermocycling in microleakage of composites.* Operative dentistry 1992, suppl 5, 42-50

29. **RL Erickson.** *Surface contamination of dentin adhesives materials.* Operative dentistry 1992, suppl 5, 81-94.

30. **Harald O, Heyman N, Stephen C. Rayne.** *Current concepts in dentin bonding.* Journal Of American Dental Association 1993, 129, 40-42

31. **D. Hugo Reteif, Razallia, S Mandras.** *Evaluation of the Syntac bonding system.* American Journal of dentistry 1993, 6(1), 17- 21 D.

32. **J Xie, J M Powers, R S McGuckin.** *In Vitro bond strength of two adhesives to enamel and dentin under normal and contaminated conditions*

Dental Materials 1993, 9, 295-299

33. **Andrew L Sonis.** *Effect of a new bonding agent on bond strength to saliva –contaminated enamel .* Journal Of Clinical Orthodontics 1994, 27,93-94.

34. **J Perdiago, EJ Swift, DE Denhy, JS Wefel, KJ Donly.** *Invitro bond strength and Scanning Electron Microscope evaluation of dentin bonding system to different dentin substrates.* Journal of Dental research 1994, 73, 44-55.

35. **Rossomando KJ, Wendt SL.** *Thermocycling and dwell times in microleakage evaluation for bonded restorations.* Dental materials 1995, 11(1), 47-51.

36. **Fitchie JG, Puckett AD, Reeves GW.** *Microleakage of new dentin adhesive comparing microfilled and hybrid resin composites.* Quintessence International 1995, 26(7), 505-10.

37. **Reeves GW, Fitchie JG, Puckett AD.** *Microleakage of new dentin bonding systems using human and bovine teeth.* Operative dentistry 1995, 20,230-235.

38. **Thomas Jacobsen, Karl- Johan Suderholm.** *Some effects of water on dentin bonding.* Dental materials 1995, 11, 132-135.

39. **Paula R Walshaw, Doroth MC Comb.** *Clinical considerations for optimal dentin bonding.* Quintensse International 1996, 27, 619-625.

40. **AUJ Yap, AN Stokes, GJ Pearson.** *An in vitro microleakage study of a new multi purpose dental adhesive system.* Journal of Oral rehabilitation 1996, 23,302-308.

41. **Jee-Won Choi, James l Drummond, Raynard Dooley.** *The efficacy of primer on sealant shear bond strength.* Pediatric Dentistry 1997, 19(4),286-288.

42. **E. Bonilla Z Yu.** *Microleakage of new "single " component dentin bonding agents* .Journal of Dental research 1997, 76, 64

43. **Marco Ferrari, Guido Goracci.** *Bonding mechanism of three " one-bottle" systems to conditioned and unconditioned enamel and dentin .* American Journal of Dentistry, 1997, 10(5), 224-230.

44. **AUJ Yap , KS Ho, KM Yong.** *Comparison of marginal sealing ability of new generation bonding agents.* Journal Of Oral Rehabilitation 1998, 25, 666-671.

45. **Tulunoglu, H Bodur, M Uctasli, A Alacazi.** *The effect of bonding agents on the microleakage and bond strength of sealant in primary teeth.* Journal Of Oral rehabilitation 1999,26, 436-441.

46. **El Kalla IH, Garcia Godoy F.** *Effects of saliva contamination on micro morphological adaptation of single bottle adhesives to etched enamel.* Journal of Clinical Pediatric dentistry 1999, 74(1), 69-74.

47. **El Kalla IH.** *Saliva contamination and resin micro morphological adaptation to cavity walls using single bottle adhesive.* American Journal Of Dentistry 1999, 12(4), 172-176 .

48. **Raphael Pilo, Ariel Ben-Amar.** *Comparison of microleakage for three one-bottle and three multi-step dentin bonding agents.* Journal Of Prosthetic dentistry 1999,82,209-213.

49. **Donald C Schmitt, Jacob lee .** *Microleakage of adhesive resin systems in the primary and permanent dentitions.* Pediatric dentistry 2002, 24, 587-593

50. **T Dietrich ,M Kraemer, GM Losche, KD Wernecke.** *Influence of Dentin Conditioning and contamination on the marginal integrity of Sandwich Class II restorations.* Operative dentistry 2000, 25, 401-410.

51. **Cristiane Maroite Amaral, Aria Karina Bedran, Pigmenta.** *Influence of resin composite polymerization techniques on microleakage and microhardness.* Quintessence International 2002,33,685-689.

52.**AA El-Housseiny, N Farsi.** Sealing ability of a single bond adhesive in primary teeth: an in vitro study. International Journal of Pediatric Dentistry 2002,12, 265-270.

53.**Thomas pioch,Hans Jorg Stachle, Marcus Wurst, Heinz , Christof Dorfer.** *The nanoleakage Phenomenon: Inflence of moist Vs dry bonding.* Journal Of Adhesive dentistry 2002,1, 23-30

54.**M Miyazaki, K Iwasaki, H Onose.** *Adhesion of single application bonding systems to bovine enamel and dentin .*Operative Dentistry 2002, 27, 88-94.

55. **Ruya Yazici, Messeret Baseren, Dayangac.***The effect of current generation bonding systems on microleakage of resin composite restorations.*

Quintessence International 2002,33,763-769.

56.**Danielson Guedes Pontes, Adriana Tavares de Melo, Antonio Fernando Monnerat.** *Microleakage of new all-in-one adhesive systems on dentinal and enamel margins.* Quintessence International 2002, 33,136-139.

57.**C Lucena Martin, MP Gonzalez Rodriguez, CM ferrer-luque.** *Study of the shear bond strength of five one-component adhesives under simulated pulpal pressure.* Operative dentistry 2002, 24, 73-80.

58. **RM Gagliardi, RP Avlar.** *Evaluation of microleakage using different Bonding agents.* Operative Dentistry 2002, 27,382-386.

59. **D. Duangthip, A Lussi.** *Microleakage and Penetration ability of resin sealant Versus Bonding system when applied following Contamination.* Pediatric dentistry 2003, 25(5), 505-511

60. **Suzanne Szep, Nichole lagner, Silja Bayer, Diana Bornichen.** *Comparison of microleakage on one composite etched with phosphoric acid or a combination of phosphoric and hydrofluoric acids and bonded with several different systems.* Journal Of Prosthetic dentistry 2003,89,161-169.

61. **LW Shook, EW Turner, J Ross, M Searbeez.** *Effect of Surface roughness of cavity preparations on the microleakage of Class V resin composite restorations.* Operative dentistry 2003, 28, 779-785.

62. **E Koliniotou Koumpia, P Dionysopoulos, E Koumpia.** *In vivo evaluation of microleakage from composites with new dentin adhesives.* Journal of Oral rehabilitation 2004,31, 1014-1022.

63. **Ramin Atash, Astrid vanden Abbeele.** *Sealing ability of new generation adhesive Systems in primary teeth: an in vitro study.* Pediatric dentistry 2004, 26(4), 322-28.

64. **Ario Santini, Vladimir Ivanoc, Richard Ibbetson, Egle milia.**

Influence of Cavity configuration on microleakage around Class v restrations bonded with Seven self etching Adhesives .Journal of Esthetic and restorative dentistry 2004, 16, 128-136.

65. **Arzu Pinar, Elif Sepet, Gamzes, Nilufer Bolukbasu.** *Clinical performance of sealants with and without bonding agents.* Quintessence International 2005,36(5), 355-360.

66. **Tar AW, Xavier lepe, Glen H Johnson, Lloyd A Mancl.** *A three year clinical evaluation of two-bottle versus one-bottle dentin adhesives.* Journal Of American Dental Association 2005,136, 311-322.

67. **Theodosis N Kallenos, Emad Al-Badawi, GE White.** *An in vitro evaluation of microleakage in Class I preparations using 5th, 6th and 7th generation composite bonding agents.* The Journal Of clinical Pediatric Dentistry 2005,29(4), 323-328.

68. **Kinloch AJ.** *Adhesion and adhesives: Science and Technology, London and Newyork, Chapman II Hall.1987.*

69. **Bowen, RL Cobb, EN Rapson.** *Adhesive bonding of various materials to hard tooth tissue surfaces, improvement in bond strength to dentin.* Journal of Dental Research 1982, 61, 1070-1076.

70. **Nobuo Nakayashi.** Operative dentistry 1992, Suppl 5, 125-130.

71.**Nordenvall , Brannstrom.** *Invivo resin impregnation of dentinal tubules.* Journal of Prosthetic Dentisty 1980, 44, 630-637.

72.**John W. Farah, John M. Powers.** *Self etching Bonding agents.* Dental Advisor 2003, 20,8

73.**M. E. Johnson, J O Burghess, C B Hermesch.** *Saliva Contamination of dentin bonding agents.* Operative Dentistry 1994, 19, 205-210

74.**Lender JJ , Swift E Jr.** *Microleakage of two new dentin adhesives .* American Journal of Dentistry 1994, 7(1), 31-4.

75.**Legler L.R, Retief, D H Bradley.** *Effects of phosphoric acid concebtrationand etch duration on enamel depth of etch; an invitro study.* American Journal of orthodontics and Dentofacial Orthopedics 1989, 98, 154-160

76.**Bates , D Retief, D H Jamison, H C Denys.** *Effects of acid etch parameters on enamel topography and composite resin enamel bond strength.* Pediatric dentistry 1982, 4, 106-110